Journal of Computer Science
https://dergipark.org.tr/en/pub/bbd
Anatolian Science

ISSN,e-ISSN: 2548-1304
Volume:9, Issue:1, pp:18-31, 2024
https://doi.org/10.53070/bbd.1410394

Research Paper

NotFYCEX: A Simulation Based Price Prediction and Notification System Using Continuous Machine Learning Method

E.N. Osegi[1*], V.I.E. Anireh[2], J.I. Mgbeafulike[3]

[1]Department of Computer Science, National Open University of Nigeria (NOUN)

[2]Department of Computer Science, Rivers State University, Nkpolu, Rivers State, Nigeria

[3]Department of Computer Science, Chukwuemeka Odumegwu Ojukwu University, Uli, Anambra State, Nigeria

(emmaosegi@gmail.com, anireh.ike@ust.edu.ng)

Received:Dec.28,2023 Accepted: Feb.05,2024 Published:Jun.01, 2024

Abstract— This research study presents NotFyCEX - a price notification systems model based on Internet of Things (IoT) and Blockchain technology for reporting important trends in a Cryptocurrency Exchange (CRYPTEX) market. The system is simulated in near real time using a co-simulator approach including web-based PHP server-side application for emulating price fluctuations, a dynamic neural network model application integrated within the MATLAB/SIMULINK software environment and ArduinoUNO hardware for continual physical signalling/alerting. Dynamic simulation results showed exact matches between synthesized price state representations and the predicted pattern states. Thus, we consider NotFyCEX a novel effort that can effectively serve as a notification and price prediction system to the end-user or cryptocurrency trader in a given CRYPTEX market.

Keywords : *Blockchain, cryptocurrency, machine learning, notification system, prediction, simulator.*

1. Introduction

One of the benefits and key indicators of economic growth is in the development of more reliable and highly efficient financial products useful as a means of exchange and that can stand the test of time particularly with respect to huge volumes of transactions per second. In this regard, the well known financial blockchain product – the cryptocurrency, which refer to highly encrypted (secure) digital type of monies, presents a key game changer in the rapidly evolving financial industry as they do offer incredible speeds ranging from hundreds to thousands of transactions per second (tps). This obviously supersedes the performance of virtually all existing traditional financial systems used till date.

The use of cryptocurrencies is no longer a new thing as both developing and the so called developed economies of the world are gradually adopting this technology amidst regulatory concerns. This is due to the power of the blockchain technology, which serves a large set of cryptocurrencies. Indeed, the blockchain and IoT technology has also shown to be valuable in a wide variety of applications including such areas as smart secure agriculture (Aliyu & Liu, 2023), community-focused healthcare (Dang et al., 2019) and the recent edge based IoT applications in the field of smart transportation, smart city, and smart grid (Gadekallu et al., 2021).

In the context of digital financial markets, trading in these virtual currencies (cryptocurrencies) demands that adequate information on the buys and sells (buy and selling pressure) be provided to the adopter (end user or trader) of the trading platform of interest. This is achieved using notification alerts or messaging by the Cryptocurrency Exchange (CRYPTEX) – the trading platform in the blockchain digital market space.

Trading (exchange of cryptocurrencies) in CRYPTEX markets is often characterized by a closed form of interaction between the user and the exchange(s) and the price alerting feature provided might not always be flexible to every user particularly when convenience is of utmost importance. However, quite a number of exchanges now provide an avenue for users to explore and add more functionality to their trades through Application Programmer Interfaces (API). Thus, if a trade is gaining, a notification alarm should be sent to the end user using NotFyCEX app.

Indeed, in keeping up with the visions of the Industry 4.0 specifications, it is imperative that applications such as NotFyCEX incorporate IoT devices in the alerting process (Bakar et al., 2023). Thus, the notification system can be made more interesting and useful by interconnecting with existing hardware such as light bulb or a real alarm in the home or office for very busy people using internet capable device. In particular, in the context of IoT ready systems and leveraging on the hybridization of IoT and blockchain technologies, NotFyCEX can parse short messages (SMS) to end users when transactions on the ledger of a given cryptocurrency exhibit important trends (e.g. consistent buys). It can also serve as Proof of Billing (PooB) in the case of utility bills payment and verification by integrating both the user (utility customer) transaction records with IoT ready SMS systems.

In this study, a tool coined NotfyCEX - for machine-internet IoT Notification as a Service (NaaS), is proposed for use by traders in experimental CRYPTEX markets.

2. Related Works

The current research on notification systems for a broader community of traders in CRYPTEX markets is one that represents a key feature in many prominent exchanges. Many of the top exchanges such as Binance, MEXC global and Coinbase do offer standard alerting services as optional add-on features to their teeming customers. However, these services are closed in the sense that it is not possible to modify the codes behind them. Hence, some of these exchanges provide Application Programmer Interface (API) tools and Starter Development Kits (SDKs) to support the development of end-user oriented alert (notification) solutions.

The APIs typically are implemented as blockchain oriented standard templates by the CRYPTEX developing them and are usually created by their developers or devs for short. These API are to be used by other software developers or programmers such that they can develop specific applications tailored to user needs and based on the available template specifications on blockchain network. In addition and with extra effort, they can also create their own application libraries or containers for running various applications on the network.

In addition to the CRYPTEX, the alerting services may also be derived from price tracking sites using as well their API tools. Some of these service agents include CoinGecko, CoinMarketCap and CoinCarp. However, these services cannot offer comprehensive real time market statistics as trding across various exchanges might exhibit large trade volume and price variations hence the need for specificity in the CRYPTEX of consideration. This situation is equally validated by the formation of new All Time Highs (ATHs) and equally All Time Lows (ATLs) making the definition or manual specification of price alert threshold limits used in real time trades unreasonable. The use of existing infrastructure for most alerting functions involves basically the specification of the CRYPTEX or price notification service API program and particularly the research in simulator-based approaches is lacking.

In this section, the related studies as it pertain to the field of blockchains and in particular cryptocurrencies and their alerting or notification schemes are discussed succinctly.

2.1. Related Works

The studies on cryptocurrency trade alerting systems or blockchain based systems combined with the Internet of Things (IoTs) is an emerging one for which a select few researchers have primarily investigated the potentials of integrating blockchains with financial instruments and IoTs.

Alabdali et al (2022) proposed a comprehensive blockchain based IoT solution based on a set of satisfiable criterion including but not limited to foods status notification, product expiry notification and product quantity checking. An Arduino processor is used to implement a physical computing platform which links to the Blynk app for seamless interconnectivity and end user navigation. However, the authors do not integrate any form of cryptocurrency in their solution.

Parikh & Banerjee (2021) proposed an Auto-bot that supported price notification via the Bolt IoT and the Ubuntu terminal app. Their system employed a decision based logic including features such as stop-loss, profit-margin determination and low-risk signaling. They implemented their notification service considering buzzer and led based signal alerting hardware units. They also employed Twilio messaging service for remote sms commands to user.

Shankhdhar et al (2021) proposed a Bitcoin price alerting system comprising of a decision making logic, machine learning (linear regression models) and deep learning algorithms such as Long Short Term Memory (LSTM) ANN. Separation of functions of Decision Logic (DL) and Machine/Deep Learning (MDL) algorithms in which the DL sends alerts signals to hardware (buzzer through cloud API) or SMS/email and the MDL sends the predicted results. They used a total of six software libraries/tools to implement their proposed solutions.

Srinivasan et al (2020) proposed a Bitcoin alert system with Bolt IoT integrated. Their system employed a decision logic and similar hardware signaling feature as in (Parikh & Banerjee, 2021). They also used e-mail notification as an add-on remote messaging feature.

Chhem et al (2019) proposed an anomaly detection systems based on stacked LSTM ANN and a real-time price notification system to alert the users of anomalous price patterns as predicted by LSTM.

2.2. Selected Use Cases
Some of the key use cases are discussed briefly under the paragraphs that follow.

The Bolt Bitcoin IoT Alert System (Agarwal et al., 2022)
This system employed a Python program as well to alert the trader when the selling price of the Bitcoin cryptocurrency is higher than a pre-set threshold. To achieve the aforementioned function, the Bolt IoT Wi-Fi module chip and a cloud computing messaging service called Twilio. The flowchart of such an application is as shown in Figure 1.

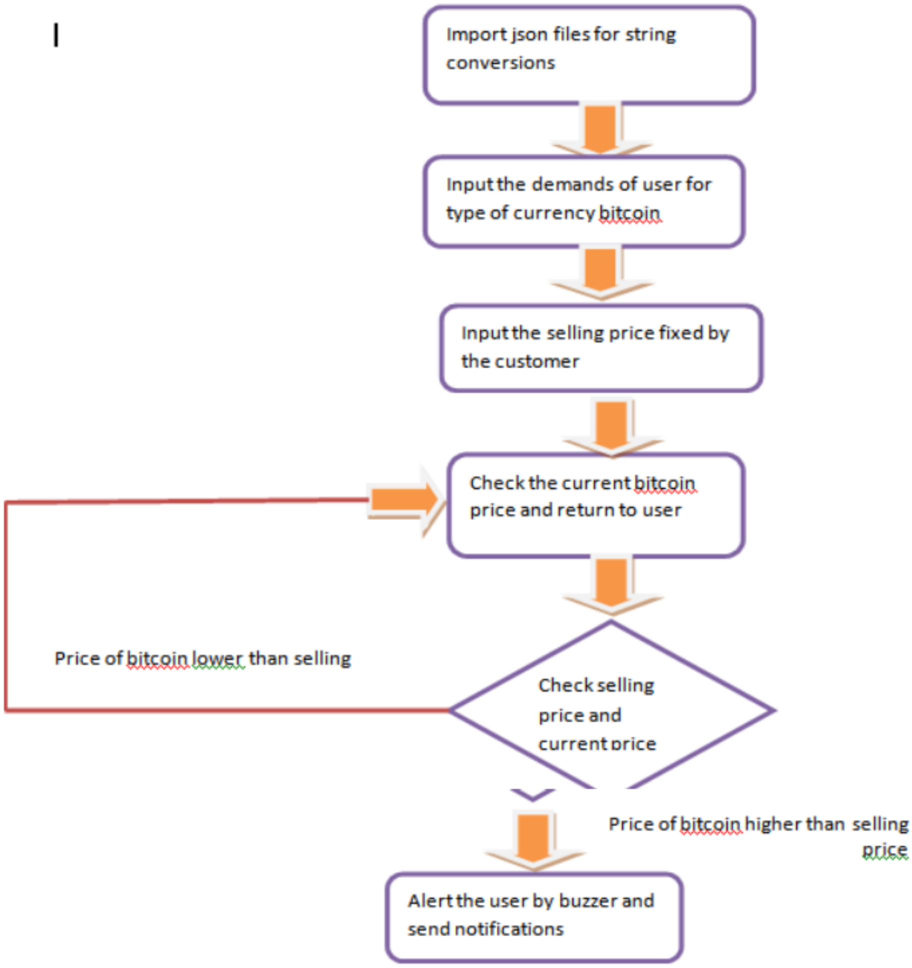

Figure 1. The Bolt Bitcoin IoT Alert System Flowchart(Agarwal et al., 2022)

The Bolt IoT Alert System (Devkar et al., 2023)
This system is similar to that used in Agarwal et al (2022) and employed a Python program and the Twilio messaging service as well to alert the trader when the selling price of a selected cryptocurrency from a menu list is higher than a pre-set value. The system which is based on autonomous alert engine (see Figure 2) checks whether the traded cryptocurrency price is higher than a user specified set threshold; if this condition is met it triggers an alert signal which can be sent to a buzzer, led or by SMS (see Figure 3).Furthermore, the CoinGecko API was used to retrieve and parse real time cryptocurrency trading data as json to the cloud service.

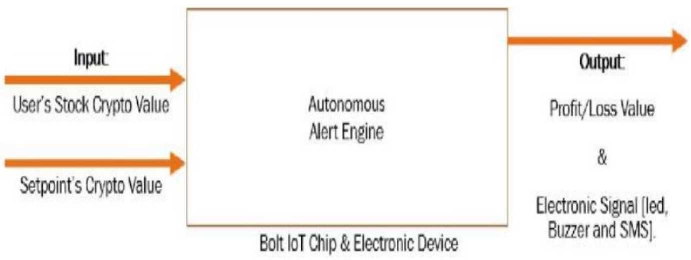

Figure 2. The Bolt IoT Input-Output Control Model (Devkar et al., 2023)

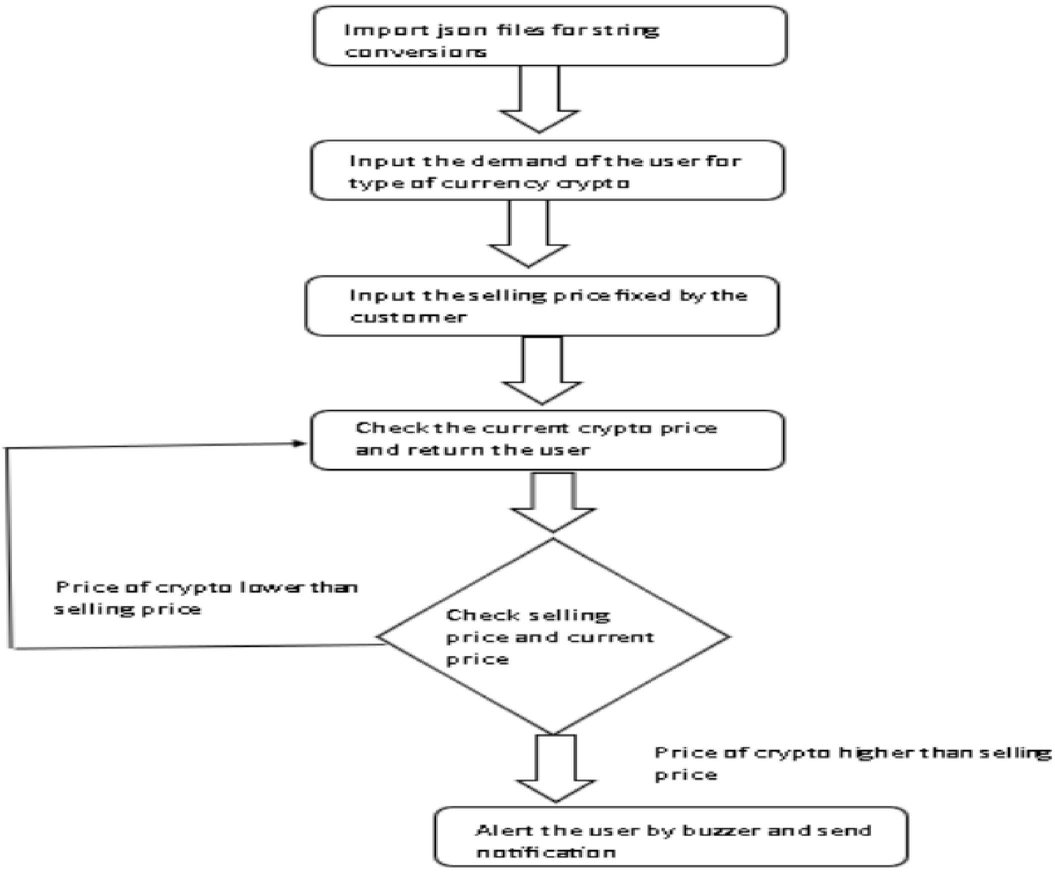

Figure 3. The Bolt IoT Alert System Flowchart (Devkar et al., 2023)

Real Time Cryptocurrency Price Tracking System (Naik & Jaipurkar, 2023)

This system is a web app (cryptoworld) which usedthe Python program to track cryptocurrency prices real time (see Figure 4). It also offered support for tracking historical prices by specifying start and end dates. The CoinGecko API was used to retrieve and parse real time cryptocurrency trading data as json using a web socket server-side service.

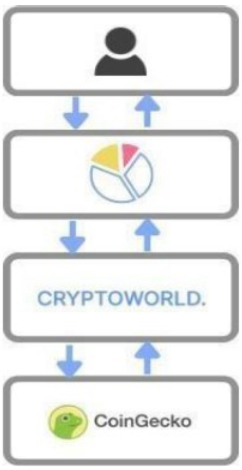

Figure 4. Price Tracking Flowchart(Naik & Jaipurkar, 2023)

2.2 Identified Knowledge Gap

The reviews so far underscores the fact that emphasis has been on identifying if a user has attained an expectation profit margin and hence notify the user. This is simple and useful enough but does not capture the inherent (hidden) price direction patterns. In particular, the existing approaches fail to address the question:

Is it likely that for a finite (short-time span), the price follows an upward or downward trend?

Thus, to answer this important question demands that the processing logic deployed is not just a simple if-else decision loop but one capable of intelligently learning the price regime over time and making informed and highly accurate guesses of price trend over time as well. This makes for a more useful notification system which will enable the user to make a more reliable decision on whether or not to invest in a particular tradable cryptocurrency. It can be clearly seen that the simulator-based approach to the study of cryptocurrency notification systems is also clearly lacking. In addition, the schemes that employ Artificial Neural Network (ANN), lack the continual learning property which is an important ingredient for intelligent agents (Hawkins et al., 2010; Hawkins, 2021).

Thus, this study will seek to address these issues by implementing a simulator-based solution with price trend direction capability and that exploits the continual learning property of ANNs.

3. Materials and Methods

The development of a system requires the clear-cut definition of the primary materials utilized in the design process as well as in the building process. In this study, the materials used for the development of NotFyCEX App – a notification (trade alerting) for centralized CRYPTEX markets is presented. The system comprises of both software and hardware parts making up for an integrated embedded systems model approach. The core design (software modeling) tools employed, and the hardware tool specifications are as listed in Tables 1 and 2 respectively.

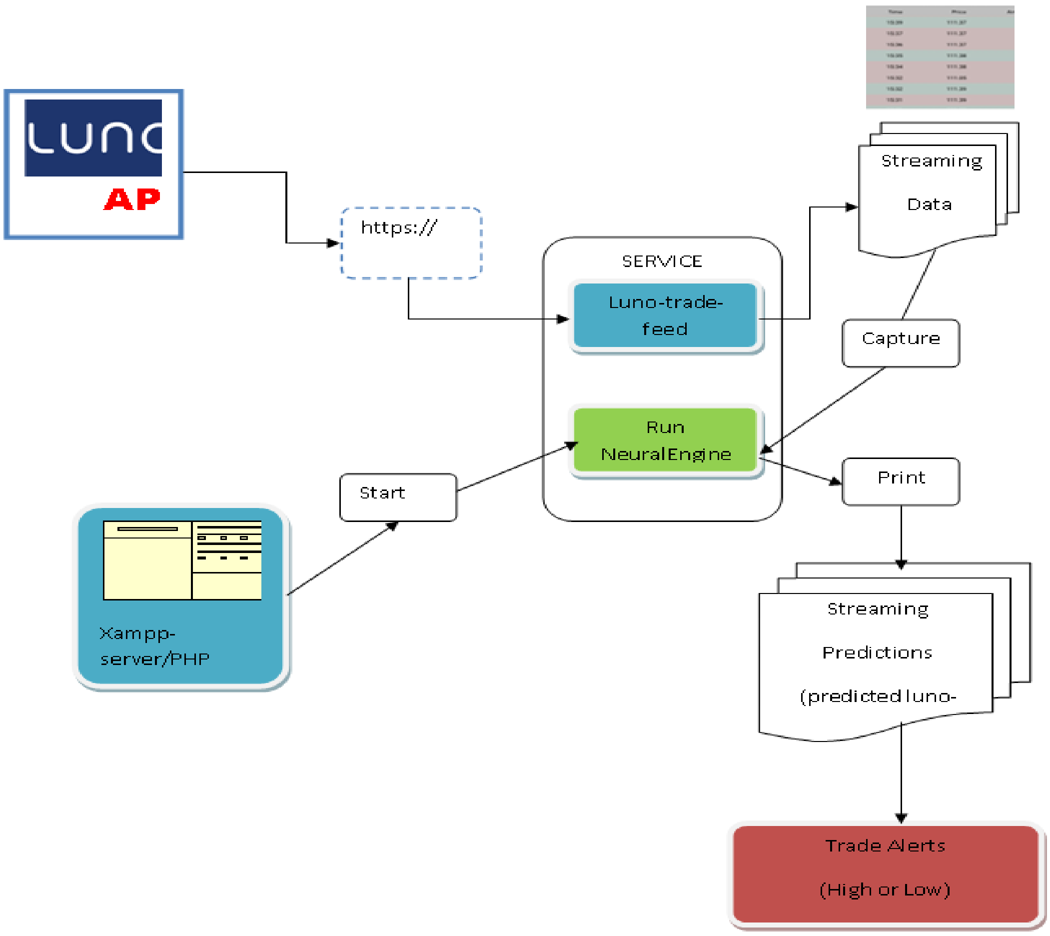

Figure 5. NotFyCEX Proposed System Architecture for real time trade alerting (Osegi, 2021)

Table 1. Software Specifications

id	Tool Name	Function	Version/Model Type
1	PHP/HTML	Web development and server processing	PHP5.3
2	MATLAB/SIMULINK	Model development and simulation	R2007b; R2023b
3	ArgoUML	Use case design	V0.34

Table 2. Hardware Specifications

id	Tool Name	Function	Version/Model Type
1	PC	General system development and data processing	Intel i-core5
2	ArduinUNO	Embedded hardware simulator	R3
3	LEDs	Cryptocurrency Visual Alert	White LED; 200mA

3.1. Methods

The methodology employed is based on systematic profiling of the scientific (step-by-step) method and the experimental approach in a hybridized case study manner coined HECS (Osegi, 2021). Using this approach allows the problem to be diagnosed effectively by identifying and representing causal relationships and their expected outcomes while focusing on a given case systematically.

3.1.1. Proposed Architecture

The architecture for implementing and evaluating the NotFYCEX App is as depicted in Figure 5; also shown in Figure 6 is the systems level bottom-up model flow showing the different stages in the modeling process and the corresponding soft and/or hard tools that were adopted in this study.

As shown in Figure 6, the primary input to the system is a data block comprising of streaming set of trade data (*n.XRP*) where *n* represents the numerical value, and *XRP* the optional symbol of the cryptocurrency being traded. These streaming data is synthesized in the server using a random number generator that is confined within a finite range of between 25 and 28 units. In the case of the simulator, the symbol is unnecessary as the representation is assumed to be general enough.

This data is fed to the sequence former block for synthesizing a 3-level state representation of the input trade streams followed by neural predictions of the state representations, bi-level signal alerting {3|1(2)} and parsing signal alerts to display or buzzer.

3.1.2. Model Assumptions

Before a model can be put into action i.e. implemented, certain assumptions have to be provided as a rule to guide the process of analysis. In this study, the following assumptions are presented:

i. Cryptocurrency under study is in the popular domain and widely traded
ii. Trading operation in the CRPTEX on selected currency do not operate a pump and dump scheme - refer to Kamps & Kleinberg (2018) and La Morgia et al (2023) for more details.
iii. Price regime is generated continually and changes within a pre-specified lower and upper bound; this is seldom true in practice as new ATH or ATL may be formed.

3.1.3. Use Case Model

The use case model depicts the core actors and what they act on i.e. the various cases. The generalized use case shown in Figure 7 is considered in this study.

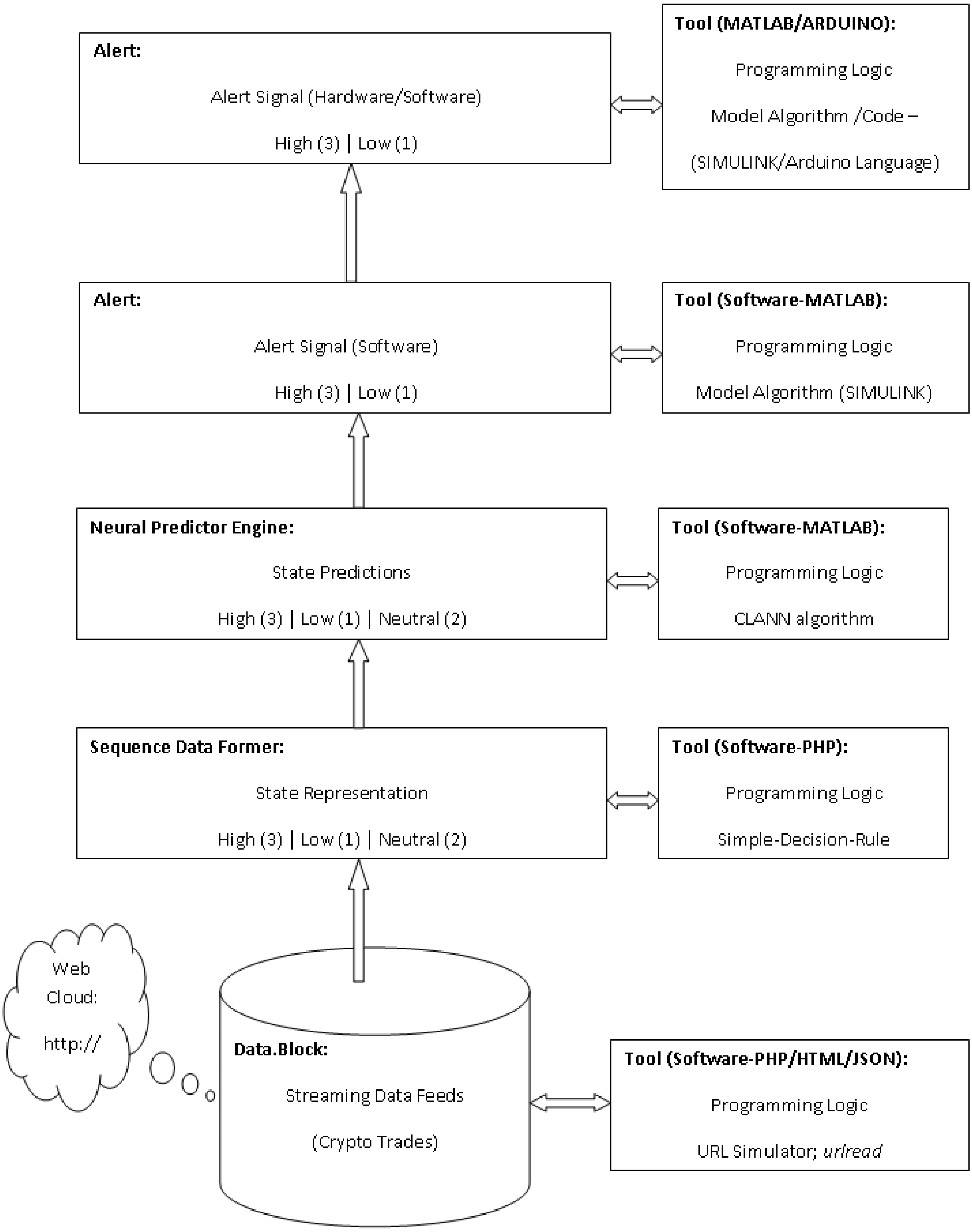

Figure 6. NotFyCEX System Modelling Flow.

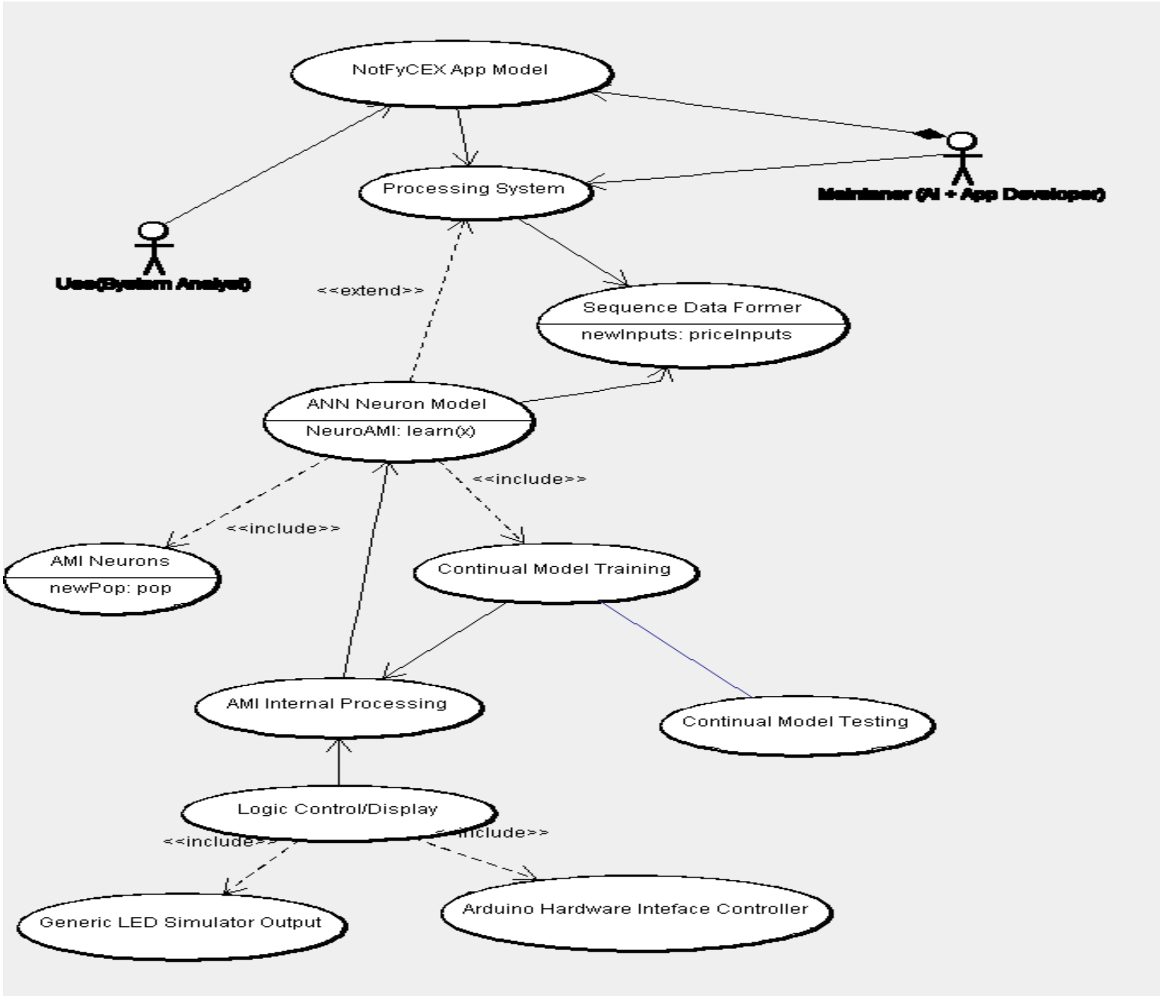

Figure 7. NotFyCEX Use Case

3.1.4. ANN Model

The ANN model proposed (Neuronal Auditory Machine Intelligence – NeuroAMI) follows from the ideas earlier proposed in (Osegi & Anireh, 2020). It uses an auditory inspired technique to achieve a sparse connection of neuron links and learns continually on sequential or streaming data using Hebbian-like updates.

The proposed architecture of the ANN used is as shown in Figure 8.

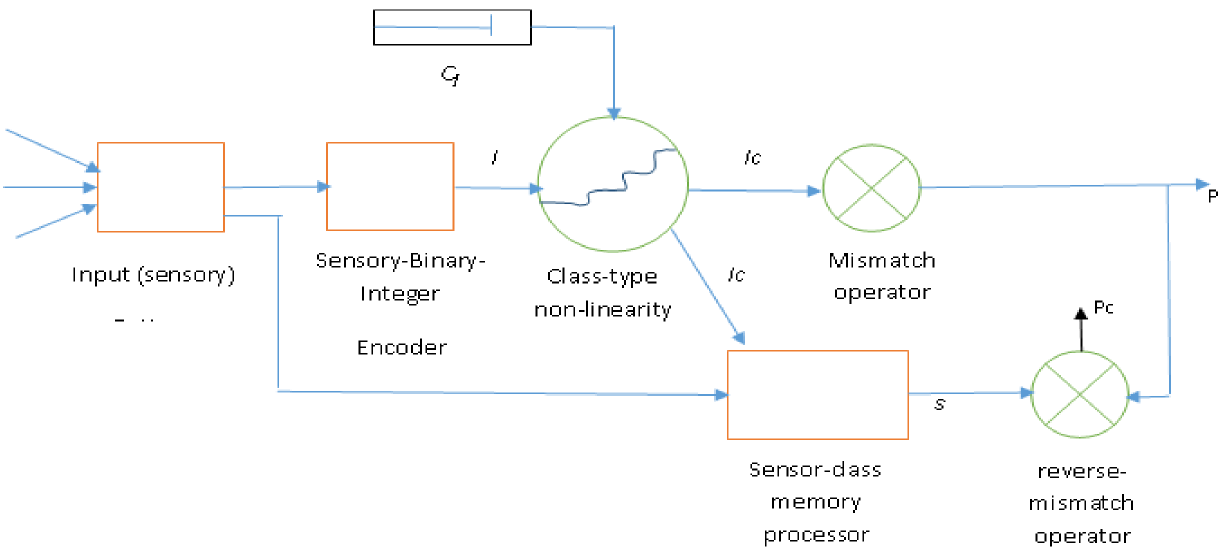

Figure 8. NeuroAMI ANN Model (Osegi, 2023)

where, as shown in Figure 4,

I_c– Integer class-type coding
P – Output Prediction
P_c – Predicted cell (neuron)
s – Sensory memory cell (neuron)
C_f – represents a frequency class signal level for tuning the class-type non-linearity

3.2. NotFyCEX Model App

The front-end interface of NotFYCEX app showing the Embedded MATLAB function block, the displays and associated data transfer (To Workspace), logic operator (Compare To Constant) and data type conversion blocks is as shown in Figure 9.

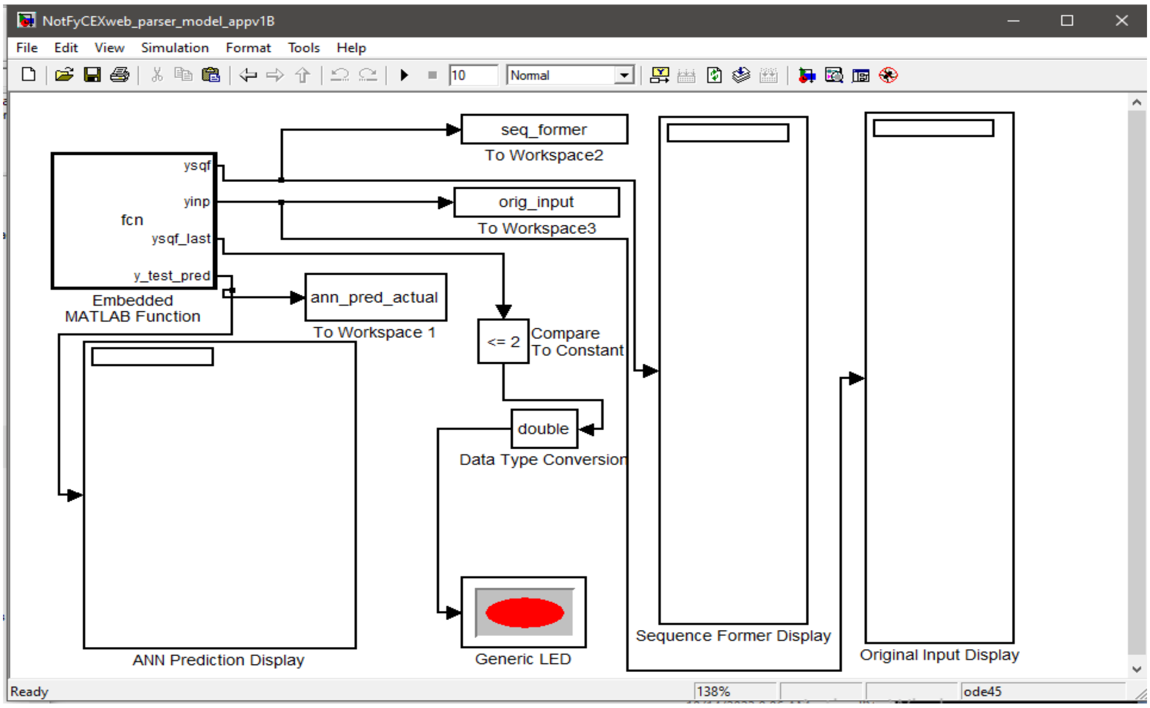

Figure 9. NotFyCEX Model App in MATLAB-SIMULINK IIDE

The Embedded MATLAB Function (EMF) block contains the codes used in making remote calls to the remote server that generates the price simulations. It does this by making http requests to the server price simulator located at http://sure-gp.com.ng/pricesimulator.php using the MATLAB *urlread* function. It also contains codes that form the state sequence representations (described as the sequence data former) and that makes function calls to the continual learning ANN functional class code (Osegi, 2021).
The important variables returned (outputted) by the EMF block and that form the basis of analysis in this study are:

i. The original input price trade values – *yinp*
ii. The sequence data former state representations – *ysqf*
iii. The ANN test outputs – *y_test_pred*, and
iv. The last predicted ANN output – *ysqf_last*

The complete systems set up including interface to real embedded hardware that supports TCP/IP and Ethernet protocols for IoT based applications is as shown in Figure 10.

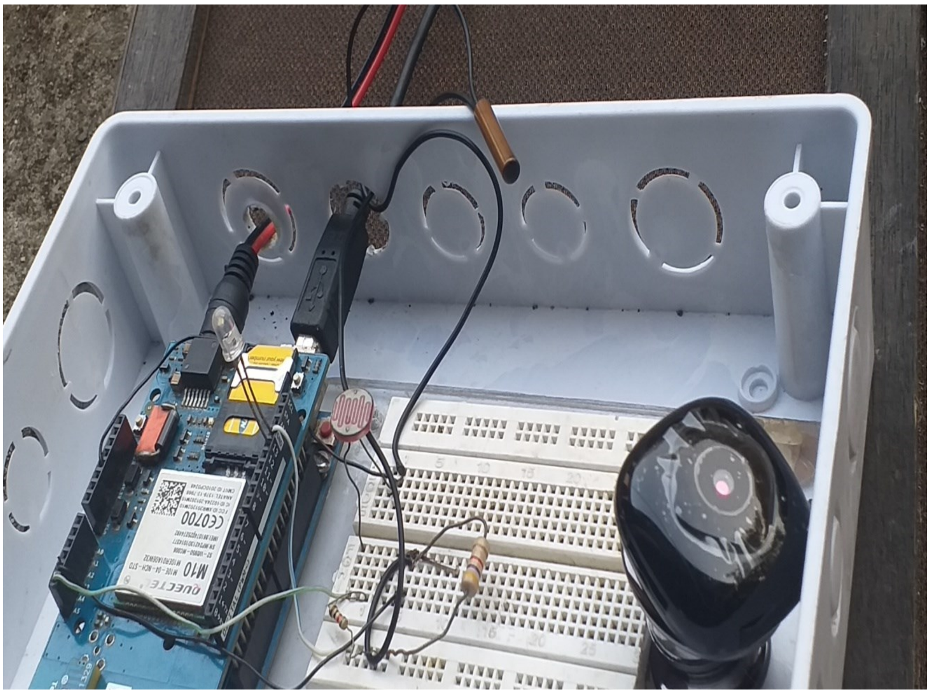

Figure 10. NotFyCEX Systems Hardware Setup

4. Results and Dıscussıons

The results using the NotFyCEX systems model as described in Section 3 are as presented in Tables 3, 4 and 5 for the original price input sequence data, the state representations of the original input as generated by the sequence former and the price pattern as predicted by the ANN.

Table 3. Original Price Input Sequence Data

id	yinp 1	yinp 2	yinp 3	yinp 4
1	25	25	25	28
2	25	27	26	28
3	27	28	27	27
4	26	28	26	27
5	26	28	26	28
6	28	28	25	27
7	28	28	28	26
8	25	26	27	27
9	26	27	27	25
10	26	28	25	26
11	28	27	27	27
12	28	28	26	27
13	25	28	25	26
14	28	28	28	28
15	28	28	25	28
16	27	27	28	25
17	27	26	25	26
18	25	27	26	26
19	28	25	25	26
20	**26**	**28**	**25**	**28**

Table 4. State Representations of the Original Input

id	ysqf 1	ysqf 2	ysqf 3	ysqf 4
1	2	3	3	2
2	3	3	3	1
3	1	2	1	2
4	2	2	2	3
5	3	2	1	1
6	2	2	3	1
7	1	1	1	3
8	3	3	2	1
9	2	3	1	3
10	3	1	3	3
11	2	3	1	2
12	1	2	1	1
13	3	2	3	3
14	2	2	1	2
15	1	1	3	1
16	2	1	1	3
17	1	3	3	2
18	3	1	1	2
19	1	3	2	3

Table 5. Predicted Patterns by the ANN (30% training input)

id	ysqfann 1	ysqf 1	ysqfann 2	ysqf 2	ysqfann 3	ysqf 3	ysqfann 4	ysqf 4
1	1	1	1	1	1	1	3	3
2	3	3	3	3	2	2	1	1
3	2	2	3	3	1	1	3	3
4	3	3	1	1	3	3	3	3
5	2	2	3	3	1	1	2	2
6	1	1	2	2	1	1	1	1
7	3	3	2	2	3	3	3	3
8	2	2	2	2	1	1	2	2
9	1	1	1	1	3	3	1	1
10	2	2	1	1	1	1	3	3
11	1	1	3	3	3	3	2	2
12	3	3	1	1	1	1	2	2

These data (Tables 3 to 5) are obtained by taking 4 different snapshot captures for 4 different price regimes (see Appendix B for detailed snapshots). For the ANN part, the training data is set at 30% of the original input data which follows from the small data paradigm earlier proposed in (Osegi et al., 2023).
Typical snapshot captures are as shown in Figures 11 and 12 for high and low state representations respectively.

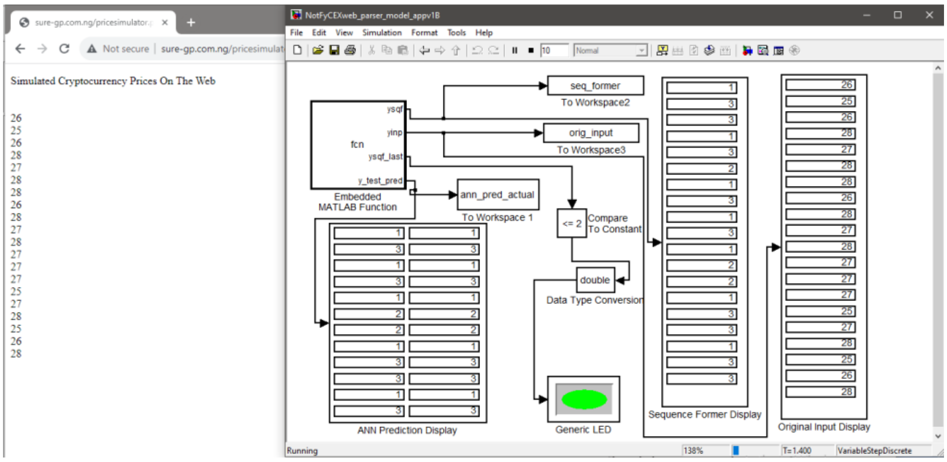

Figure 11. NotFyCEX Simulated state representation capture (High-State)

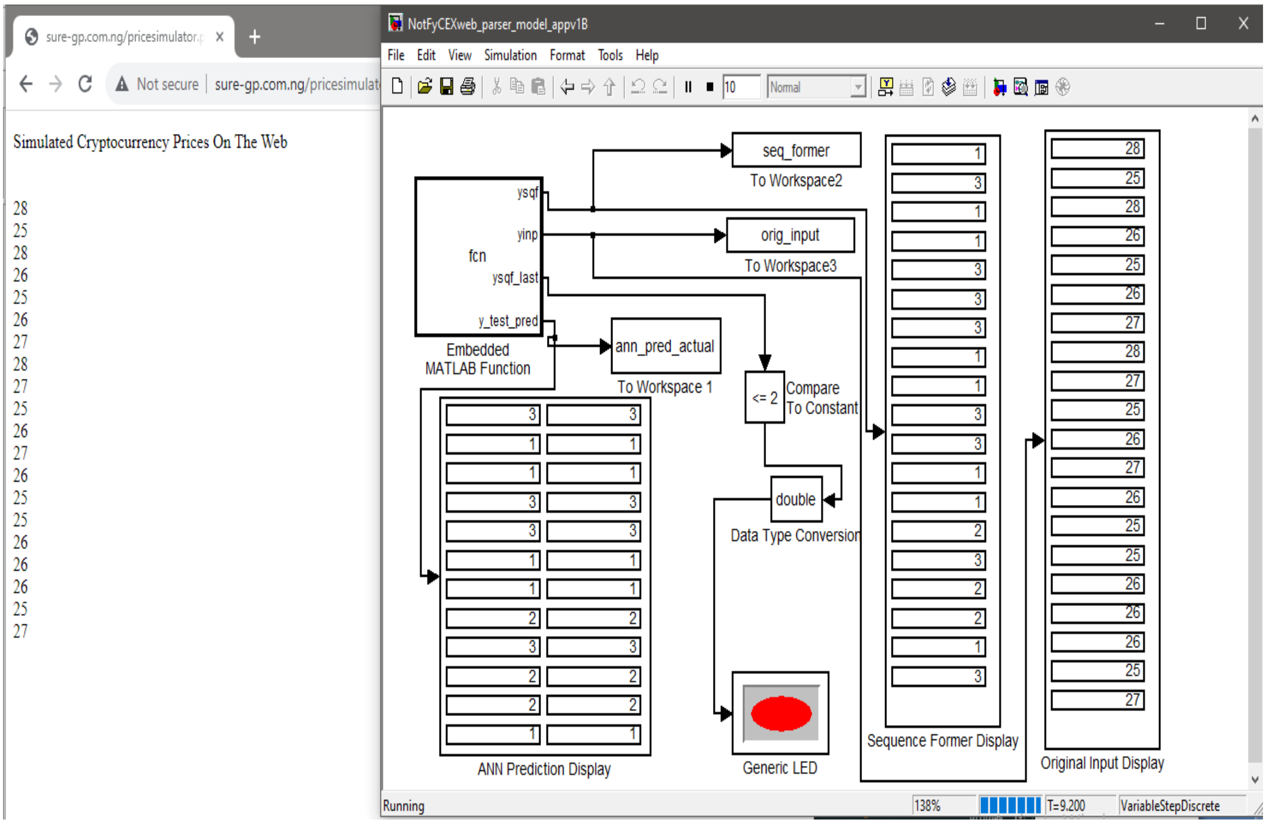

Figure 12. NotFyCEX Simulated state representation capture (Low-State)

4.1. Discussions

The results presented thus far has shown the feasibility of the model based simulator approach in dynamically capturing the notification process that may be adopted in a real world trading scenario as found in most CRYPTEX markets.

The results in Table 3 show that variation in patterns can be simulated as this enables the performance of the ANN predictor to be realistically examined. For the last patterns of the original input (yinp) in Table 4, it can be seen that there is a decrease (1), increase (3), neutral (2) and increase (3) state when compared to previous values for columns yinp1, yinp2, yinp3 and yinp4 respectively. This is also clearly replicated in the sequential formed states as in Table 5.

The results in Table 5 show the state representation patterns as predicted by the proposed continual learning ANN. As can be seen, the comparison is made between the test predicted pattern (ysqfann) and the actual test input (ysqf). It can also be clearly seen that there is exact match between the ysqfann and ysqf.

It is important to observe that the sequence length of the price values formed after state processing is reduced by 1 unit. This is due to the if-else decision logic employed. A much larger reduction in the sequence length is seen in Table 5 due to the use of 30% training data – implying remaining 70% for testing.

5. Conclusıon, Recommendatıon and Future Work

5.1. Conclusion

In this study, NotFyCEX – a notification system in the context of NaaS for CRYPTEX markets and based on a dynamic model-based co-simulator systems approach is proposed for real time trading experiments.

The system has been developed using both open-source software and hardware tools/platforms and proprietary software solutions. In addition, the system employed a continual learning ANN inspired by auditory processing in the human brain for trend signaling and alerting.

The results showed that the proposed system is able to synthesize price patterns and capture variations and important trends using neural intelligent system with good matching capability.

5.2. Recommendation

NotFyCEX is recommended primarily as an educational and research tool to facilitate the understanding and development of IoT-capable cryptocurrency trade notification systems.

It can also be useful in the field of real time control or other fields that require close monitoring and where blockchains can be a sure and authentic solution such as in pre-paid billing.

5.3. Future Work

In future, NotFyCEX will be expanded to address the following:

i. Real world trading in several real CRYPTEX markets based on proposed continual learning neural intelligent co-simulators approach.
ii. Implementing Proof of Utility Bill Payment (PoUBP) blockchain systems

Acknowledgements

The SurePay Foundations Group is hereby acknowledged.

References

Alabdali, A. M. (2022). A novel framework of an IOT-blockchain-based intelligent system. *Wireless communications and mobile computing*, 1-13.

Aliyu, A. A., & Liu, J. (2023). Blockchain-Based Smart Farm Security Framework for the Internet of Things. *Sensors*, *23*(18), 7992.

Agarwal, A., Soni, D., & Isha, A. K. Y. (2022). Bitcoin Alert System Using Bolt Iot Integrated. *International Journal of Advances in Engineering and Management,* *4*(5), 2567 – 2575.

Bakar, K. B. A., Zuhra, F. T., Isyaku, B., & Sulaiman, S. (2023). A Review on the Immediate Advancement of the Internet of Things in Wireless Telecommunications. *IEEE Access*.

Chhem, S., Anjum, A., & Arshad, B. (2019, December). Intelligent price alert system for digital assets-cryptocurrencies. In *Proceedings of the 12th IEEE/ACM International Conference on Utility and Cloud Computing Companion* (pp. 109-115).

Dang, L. M., Piran, M. J., Han, D., Min, K., & Moon, H. (2019). A survey on internet of things and cloud computing for healthcare. *Electronics*, *8*(7), 768.

Devkar, S., Divekar, R., Khandagale, P., & Khote, S. S. (2023). Crypto Alert System Using Bolt IoT. *International Research Journal of Modernization in Engineering Technology and Science, 5*(10), 2829 – 2833.

Gadekallu, T. R., Pham, Q. V., Nguyen, D. C., Maddikunta, P. K. R., Deepa, N., Prabadevi, B., ... & Hwang, W. J. (2021). Blockchain for edge of things: Applications, opportunities, and challenges. *IEEE Internet of Things Journal*, *9*(2), 964-988.

Hawkins, J., Ahmad, S., & Dubinsky, D. (2010). Hierarchical temporal memory including HTM cortical learning algorithms. Techical report, Numenta. *Inc, Palto Alto*.

Hawkins, J. (2021). *A thousand brains: A new theory of intelligence*. Basic Books.

Kamps, J., & Kleinberg, B. (2018). To the moon: defining and detecting crypto currency pump-and-dumps. *Crime Science*, *7*(1), 1-18.

La Morgia, M., Mei, A., Sassi, F., & Stefa, J. (2023). The doge of wall street: Analysis and detection of pump and dump cryptocurrency manipulations. *ACM Transactions on Internet Technology*, *23*(1), 1-28.

Naik, R., & Jaipurkar, P. (2023). A web application for real-time price tracking cryptocurrency.

Osegi, E. N., & Anireh, V. (2020). AMI: an auditory machine intelligence algorithm for predicting sensory-like data. *Computer Science*, *5*(2), 71-89.

Osegi, E. N. (2021). Design and Implementation of a Web-Based AI Tool for Real Time Trading In Financial Markets. Diploma Thesis. National Open University of Nigeria (NOUN).

Osegi, E. N., Jagun, Z. O., Chujor, C. C., Anireh, V. I., Wokoma, B. A., & Ojuka, O. (2023). An evolutionary programming technique for evaluating the effect of ambient conditions on the power output of open cycle gas turbine plants-A case study of Afam GT13E2 gas turbine. *Applied Energy*, *349*, 121661.

Osegi, E. N. (2023). Neuronal Auditory Machine Intelligence (Neuro-AMI) In Perspective. http://dx.doi.org/10.13140/RG.2.2.10131.45605.

Parikh, D. P., & Banerjee, R. S. A. (2021). Design of Intelligent Auto-bot for Financial System.

Shankhdhar, A., Singh, A. K., Naugraiya, S., & Saini, P. K. (2021, April). Bitcoin price alert and prediction system using various models. In *IOP Conference Series: Materials Science and Engineering* (Vol. 1131, No. 1, p. 012009). IOP Publishing.

Srinivasan, S., Sundar, R., Immanuel, S. J. H., Belvadi, R., & Sathiyanarayanan, M. (2020, October). Bitcoin alert system using bolt IoT integrated with blockchain. In *2020 International Conference on Smart Technologies in Computing, Electrical and Electronics (ICSTCEE)* (pp. 575-580). IEEE.